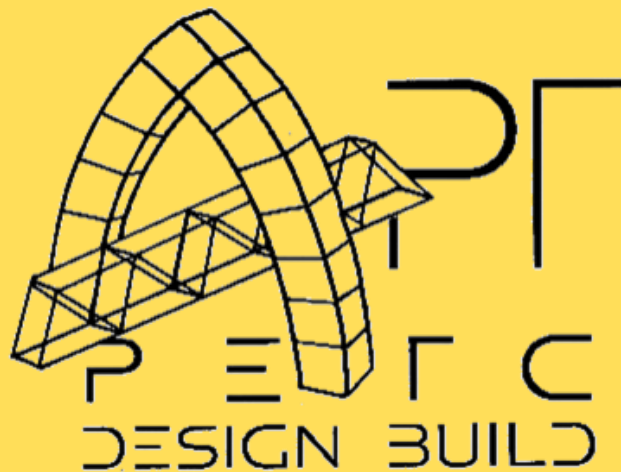


# APT PETC 2025 SPECIFICATIONS

## MASONRY ARCH

10th Annual Student Design-Build Competition



## In This Package

This package provides information about this year's Student Design-Build Competition hosted by APT's Preservation Engineering Technical Committee. In this document you will find background information, an overview of the competition phases, as well as the specifications and competition requirements.

***Take a look to see if you and your team are inspired to enter!***

## Quick Dates Guide

The following schedule is preliminary and may be subject to change. PETC will notify teams if dates or deadlines change.

DATE	ITEM	DEADLINE/INFO
<b>February 10, 2025</b>	Competition Announced and Specifications Issued	Info
<b>March 10, 2025</b>	<b>Phase 1 Submission Due</b>	<b>DEADLINE</b>
<b>March 17, 2025</b>	PETC notifies teams that will move from Phase 1 to Phase 2	Info
<b>Early May 2025 (TBD)</b>	Masonry Arch Workshop	Info
<b>July 7, 2025</b>	<b>Phase 2 Submission Due</b>	<b>DEADLINE</b>
<b>July 28, 2025</b>	PETC notifies teams that will move from Phase 2 to Phase 3.	Info
<b>November 4, 2025</b>	Final date for requests for clarifications for Phase 3	Info
<b>November 11-15, 2025</b>	<b>Phase 3 Competition at APT Conference in Providence, Rhode Island</b>	<b>CONFERENCE</b>

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# 1. Introduction

Masonry structures make up a large portion of built heritage and require specific care and understanding in order to maintain them for future generations. These structures were built according to different engineering and building science principles than modern structures, with their own inherent advantages and disadvantages in comparison to their modern counterparts.

Working with unreinforced masonry arches requires an understanding of masonry design and construction techniques, including present day technologies and those employed at the time of construction. While these types of structures are common elements in existing buildings, fewer and fewer students have opportunities to get hands-on experience into their behaviour and repair methodologies.

This year, the Association for Preservation Technology (APT) Preservation Engineering Technical Committee (PETC) Student Design-Build Competition will focus on masonry design and conservation by highlighting the intricacies of masonry arch construction and the methods employed for their preservation.

Teams will research, design, build, and test a masonry arch to understand traditional masonry construction and preservation principles. The teams selected for the Phase 3 finals will be exposed to historic construction and connected with industry professionals across the USA and Canada.

## 1.1. Competition Objectives

The key objectives of this competition include:

- Expose students to the fundamentals of researching and analyzing a historic masonry arch.
- Expose students to the materials common in masonry construction and preservation by providing a hands-on experience.
- Introduce students to preservation engineering fundamentals, using a real structure as a case study.
- Promote “out of the box” learning and problem solving.
- Expose students to real project experience elements by understanding logistics, project budgeting, and constructability constraints.
- Connect students to professionals in the preservation industry through mentoring during the on-campus work and networking during the conference finals.
- HAVE FUN!

## 1.2. Desired Learning Outcomes

The key learning outcomes of this competition include:

- Understand the value of multi-disciplinary teams.
- Learn to manage a team.
- Build networks to engage external professionals.
- Understand the basics of traditional masonry design and construction.
- Transfer design to physical construction.
- Design and execute a laboratory testing procedure.
- Learn from conference presentations and other activities.

## 1.3. Competition Framework

The competition is structured with three main phases. In Phases 1 & 2, teams will work at their home campuses on identification, analysis, and design-build components. Phase 3 will culminate with the finals at the 2025 APT Conference in Providence, Rhode Island from November 11 – 15, 2025, and will include team presentations of research, an on-site build competition, and answering preservation challenges in front of the APT community at the conference.

### Phase 1 – Preliminary Research:

- Notice of Participation
- Masonry Structure and Arch Selection

### Phase 2 – On-campus Design-Build & Report:

- Masonry Arch Build and Test
- Report on historic research, structural review and preservation plan
- Funding Plan

### Phase 3 – Conference Finals:

- “Dry Stack” Arch Build
- Presentation and Q&A Session
- Preservation Problems
- Poster

## 2. Project Team

### 2.1. Team Members

Teams are to be formed from post-secondary students from a single university (undergraduate or graduate program), college, or trade school. Teams are recommended to include engineering, architectural, and conservation/preservation students. Teams are to have a minimum of 4 people and a maximum of 6 people. Each team must name a Team Captain to liaise with PETC. An institution can have more than one team enter the competition.

If a team member must drop out of the competition after the Phase 1 team roster is submitted, the team is to notify PETC with a student substitution, if desired.

### 2.2. Faculty Advisors

Each team must have at least one Faculty Advisor, with more as desired. Their role is to advise students on technical and design issues, and to support and monitor the on-campus arch construction. Faculty Advisors also serve as a formal link to the institution for educational, construction, and/or safety matters.

### 2.3. Mentors

During Phase 2, PETC will assign teams to an APT-provided mentor who is typically a preservation practitioner in a related field. Out of respect for the mentors' time, PETC provides the following direction regarding team interactions with mentors:

- Teams will be student driven, and mentors will serve as sounding boards for ideas.
- Teams are expected to touch base with their mentor regularly for discussion.
- Teams will be responsible for scheduling meetings and to be prepared for meetings with their mentors.

Each student team is encouraged to interact with their team mentor and other professionals throughout the competition. The goal of these interactions should be, in part, to provide opportunities for the students to gain constructive feedback on their methodology and craft at critical steps throughout the competition. The teams are encouraged to self-assess their practice area strengths; determine where additional professional mentoring and guidance could be best served.

## 2.4. Contacts

The Team Captains should contact the PETC Competition Committee via email for any questions or support. Answers will be issued to all Team Captains, to ensure all teams receive the same information.

Team contact for PETC competition communications: [aptpetc@gmail.com](mailto:aptpetc@gmail.com)

## 2.5. Media

The PETC Student Design-Build Competition has no restrictions on talking to the media, and teams are encouraged to promote their work. PETC asks that articles, photographs, quotes, etc. are professional and in good taste. PETC asks to be sent a copy of any published (written or digital) articles in which the competition is discussed.

Be sure to include *#APTPETC* on social media posts.

The PETC Conference Committee will provide updates to APT members and the greater preservation community about the competition and teams. Please share photos and updates of the Phase 2 process throughout your team's work for inclusion in APT's social media platforms, APT's email Communique, and in PETC's e-blasts!



## 3. Phase 1: Notice of Participation and Arch Selection

### 3.1. Notice of Participation

Each team is to provide a written Notice of Participation which shall be a 1-page submission with the following information:

- Name of the institution wishing to participate in the competition  
*Note: If multiple teams from a single institution are submitting proposals, please provide an individual identifier (for example, specific campus location, name of arch, team number, Team Captain's surname, etc.) so as to distinguish them from other teams within the same institution.*
- Name, email, and phone number of each team member
- Year and program of study of each team member
- Identification of Team Captain
- Name, email, and phone number of the team's FaZculty Advisor(s)
- Desire to compete in Phase 3 at the conference

### 3.2. Arch Selection

Teams are to select a building with a structural masonry arch that the team can access for the required field inspection work. The arch may be an interior or exterior element of the existing structure. The selection of this arch is the keystone of the Team's research on historic construction practices and will serve as the base model for the Phase 2 arch analysis, design, and build.

The Masonry Arch Selection submission is a 400-600-word report. The report is to include the following:

- Name and location of the selected structure
- Date of construction (approximate if not possible to find the exact date)
- General information on the arch's history and construction, including its historical significance or designations
- Original materials used in its construction
- References for the literature used to understand the history and construction of the structure
- References for the historic codes that will be used to analyze the structure
- Three to five images of the arch and surrounding structure.

If a team is unable to locate a masonry arch that meets the given criteria outlined above, a non-local arch may be selected, or the team can contact the PETC Competition Committee for alternatives.

Teams are to notify the PETC Competition Committee if they have not received notification on receipt of Phase 1 documents by the committee ***within one week*** of their submission to ensure transmittal of the information to PETC was successful.

Once the team submissions are received, the PETC Competition Committee will provide feedback and/or approval of each team's submission. Teams should prepare to respond promptly to any feedback provided by the Competition Committee's questions during the review period. PETC will notify the teams that will move to Phase 2.

## 4. Phase 2: Masonry Arch Design-Build and Report

Phase 2 includes on-campus design-build and testing of the team’s scaled-down masonry arch and a report on their chosen historic arch and how they adapted it for construction of the scale version.

### 4.1. Masonry Arch Design-Build

Teams are to design and build a masonry arch out of any masonry material in accordance with competition specifications. Teams will build and load-test their arch at their home campus. Videos must be submitted for both the build and the load testing.

#### 4.1.1. Material Requirements

##### 4.1.1.1. *Masonry Units*

Teams can select any type of masonry unit, including, but not limited to, brick, stone, and terracotta.

Masonry units are to be joined with plane flat surfaces. No interlocking of masonry units beyond standard keying is allowed. No mortise and tenon, tongue and groove, and/or dowel type engagements are allowed.

##### 4.1.1.2. *Mortar*

Teams are to develop the mortar mix based upon research of historic masonry practice.

Mortar should be appropriate for historic structures. Mortar should have no, or a practically minimal, Portland cement content. Teams using Portland cement should provide their rationale. No mortar admixtures or bonding agents are permitted.

Mortar mix is to be recorded and documented in the report.

Mortar cure time and curing procedures shall be considered as part of the mortar mix design. Record curing procedures and cure time in the report appendix.

##### 4.1.1.3. *False Work*

Teams may use any material(s) to construct the arch false work.

#### 4.1.2. Assembly Requirements

##### 4.1.2.1. *Overall Arch Requirements*

Refer to Figure 1 for assembly requirements. Teams are to provide photographic and written evidence of compliance with the dimensional requirements in the Phase 2 Report. Deductions from score will be made for violations.

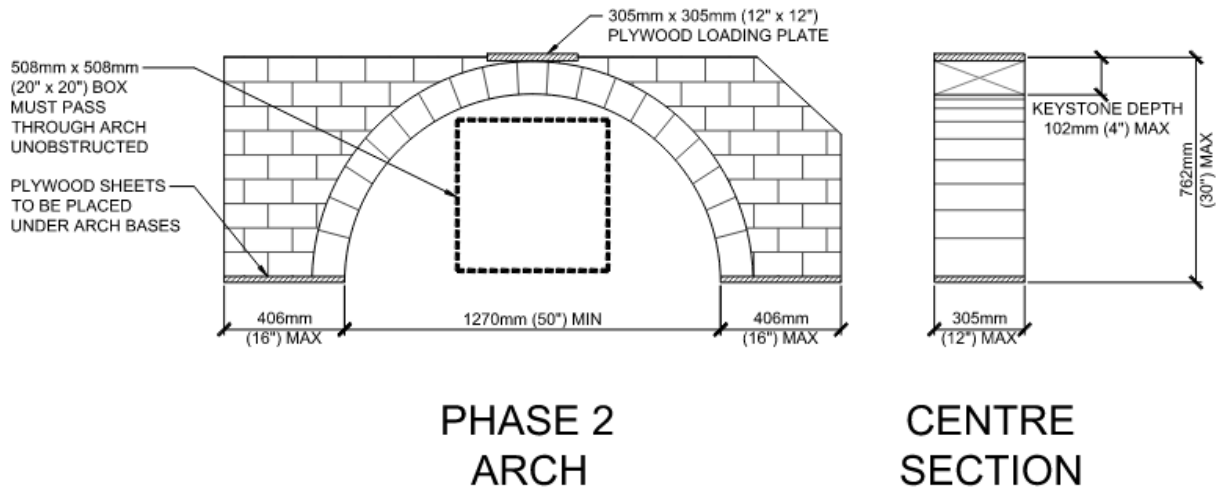


Figure 1: Sketch of the Phase 2 Arch dimensional requirements and test set-up. Team's arches do not need to look identical to the arch shown.

#### 4.1.2.2. Build Surface

The arch is to be built on a flat, smooth, and level surface, preferably an interior concrete floor slab or exterior concrete paving slab. No obstructions (shear engagement) that restrain outward movement on the build surfaces are allowed. Encountering any obstructions in the surroundings during testing will be considered as an arch failure.

Each side of the arch is to be built atop separate plywood sheets, with no mechanical attachment between the two sheets or the ground during testing.

#### 4.1.3. Construction

##### 4.1.3.1. Protocol

Teams are to document the protocol they use for arch construction and assembly, including safety protocols approved by the Faculty Advisor. This protocol is to be provided in the report appendix and showcased in a video recording of the build. See Appendix B for video requirements.

##### 4.1.3.2. Safety and Stability

Teams are to ensure all work is done safely following protocols approved by their Faculty Advisor. The following shall apply:

- All team members must wear proper Personal Protective Equipment (PPE), including steel toe boots, gloves, hard hats, and safety glasses.

- No work can be done by any team member without supervision by another team member.
- All team members must follow Workplace Hazardous Materials Information System (WHMIS) or Occupational Safety and Health Administration (OSHA) guidelines for safety and receive any supplemental lab or safety training required by their institution.

The stability of the arch during construction must be monitored to ensure no risk is posed to people or surrounding equipment.

#### 4.1.4. Safety and Supervision

At any point a team member, Team Captain, or Faculty Advisor can halt the testing if any aspect of the testing is unsafe. Judges will review video footage to ensure team members all use PPE appropriately throughout the build. Misuse, lack of PPE, or unsafe work procedures as determined by the judges using their judgement can result in point deductions.

##### 4.1.4.1. *Individual Responsibilities*

All team members are to be aware of the safety risks and abide by the safety plans approved by their Faculty Advisor. Plans should include emergency contingency plans. Personal protective equipment (PPE), inclusive of eye protection, steel toe boots, hard hats and gloves shall be worn during the build. Points will be deducted for missing PPE.

##### 4.1.4.2. *Team Captain*

The Team Captain will act as a visual observer during the arch testing, watching all aspects of the loading procedures and intervening in the case of unsafe execution.

If a safety concern is reported and the testing is halted, the Team Captain can either direct how the safety concern is to be addressed or refer to the Faculty Advisor.

##### 4.1.4.3. *Faculty Advisor*

The Faculty Advisor is to be present during testing of the arch. In the case of an unsafe condition that has not been identified by team members or team captain, the Faculty Advisor can call a halt to the testing. If the testing is halted by the Faculty Advisor, the testing shall record the load at that point as the failure load. This intervention is intended to ensure team safety.

#### 4.1.5. Loading the Arch

Teams are to have loading protocols established in writing, and all members are to be familiar with required procedures. Teams are to record a video beginning with a review of all safety measures taken before loading. While recording, teams are to load the arch to failure

or the greatest load that can be safely applied, whichever is reached first. See Appendix C for Video Requirements.

Phase 2 evaluation and judging will consider situations when an arch cannot reach failure safely after a team takes reasonable measures to find safe testing approaches.

#### *4.1.5.1. Load Procedure*

Testing is to be performed by loading a 12-inch x 12-inch x 3/4-inch-thick (305 mm x 305 mm x 19 mm) plywood square placed on the top of the arch, centered. Teams can select their own loading plans and types of weights. Based on accessibility to load testing equipment, PETC understands that multiple loading approaches may be employed. All approaches will be evaluated equally.

#### *4.1.5.2. Load Monitoring and Measurements*

Teams are to monitor the following movements during loading:

- Load increments applied to the arch, and total load placed on the arch at each increment. The total current load amount should be recorded on a card, whiteboard, or tablet that is clearly visible in the video.
- Monitor and record any displacements that occur, and the load it occurred at.
- Monitor and record any cracking that occurs, and the load it occurred at.

Teams can take measurements manually or digitally. The details of the procedure and measurements are to be documented clearly in the report appendix, with measurements reported to the nearest 1/16th of an inch or 1 millimeter.

#### *4.1.5.3. Failure Load*

The failure load is to be identified as the last recorded load at which the arch sustained the load for 10 seconds. The arch is considered to have failed once 3 cracks have opened up, or at team or faculty mentor's discretion. No points will be deducted for ending a test early due to failure concerns.

### **4.1.6. Videos**

The purpose of recording the arch build and loading with videos is to demonstrate and document the working procedure, construction approach and testing procedure, and to provide a visual for the Judges and conference attendees in Phase 3. Each team is to submit two videos that record their Phase 2 on-campus build and testing:

- **Video 1:** captures building the arch and verifies compliance to the specifications. This video documents the team's working procedures, materials (including mortar mixing), construction approach, sequence of laying the masonry units and building up the arch, and the dimensions and unique features of the team's arch.

- **Video 2:** captures the safety procedures, loading sequence, displacements/deflections at each loading sequence, and, if relevant, the failure of the team's arch. This video should see the total current load amount recorded on a card, whiteboard, or tablet and a timer placed within the view of the camera. Narration or captions may be used for clarity.

The suggested length of each video is about 4 - 7 minutes, and students are encouraged to time-lapse the repetitive and/or irrelevant portions of the work (particularly the build). Videos longer than 7 minutes may be edited by PETC for brevity. Refer to Appendix B for video requirements.

## 4.2. Report

The Phase 2 report builds on the Phase 1 submission, and consists of five main components:

- Background Research and Historic Significance
- Structural Analysis
- Preservation Plan
- Arch Design-Build Description
- Appendices

See Appendix A for specific report format requirements and Appendix D for Scoring Criteria

### 4.2.1. Background Research and Historic Significance

Teams will build upon the information presented in their Phase 1 Arch Selection narrative and prepare a more detailed report including:

- The significance of the selected structure, including its architectural, cultural/technological significance. Historic literature and reference materials should be used as a guide;
- The materials used in construction, identification of the original material source and their composition, etc.;
- Any major modifications or conservation projects completed on the structure;
- Identify and describe the structural type of the arch; and
- Archival or current photos/drawings.

### 4.2.2. Structural Analysis

Teams are to demonstrate an understanding of the structural behavior of the selected arch. Teams will assess the structural arch by utilizing methods and principles likely used in its original design and construction.

#### 4.2.2.1. *Define Relevant Loads and Assumptions*

Teams are to identify the relevant loads or conditions used in the evaluation, as well as any load combinations (if applicable). Discussion may include:

- What loads have been selected and why?
- Were any loads intentionally not evaluated?
- Is any specialized load evaluation required?

Teams are also to describe any assumptions made in their analysis regarding material properties, boundary conditions, limitations, etc.

#### 4.2.2.2. *Evaluate Performance*

Teams will evaluate the arch's performance and possible failure mechanisms. Teams shall undertake their evaluation using any **two** of the following approaches:

- Empirical Design (Classical Approaches)
- Nineteenth Century Analytical Models (Graphic Statics or Similar)
- Contemporary Structural Engineering Analytical Software

Teams must justify why at least one of the selected approaches would provide a safe analysis and comment on any limitations of the selected analysis method. The findings from the structural evaluation of the arch shall be discussed and may include the following discussion points:

- What is the ultimate load capacity of the arch? Is the arch able to resist the applied loads?
- What are the general failure mechanisms of arches?
- What are the visible signs that an arch has become over-stressed? Are there any signs that your team's selected "real world" arch is over-stressed?
- What structural interventions would you recommend to address any structural deficiencies? Are there any interventions visible on the arch which correspond to your analysis?
- Comment on how some of your assumptions may impact the capacity or failure mechanisms of your arch.
- Other noteworthy observations from your analysis.

#### 4.2.3. *Preservation Plan*

The built environment is subject to external forces that often affect the condition, materials, and structural integrity of historic structures. As preservationists, it is our responsibility to assess the condition and provide guidelines for owners on how to best conserve and maintain their assets. Teams are to conduct a visual condition assessment and identify three



conditions with their arch and/or surrounding masonry. For each condition include the following:

- Identify the condition;
- Location on the building/structure;
- Cause of the condition;
- A judgment on the severity of the condition (Is it in good, fair, or poor condition? Is it urgent to fix, or can be fixed in the short or long-term?);
- Proposed repair, treatment, or monitoring program for the condition; and
- One photo demonstrating the condition.

Various conditions may fall under the umbrella of structural issues, moisture issues, materiality, aesthetics, and issues related to maintenance. The three conditions must impact the masonry directly (e.g. cracked stone, displacement) or indirectly (e.g. poor water-shedding). Conditions which only impact non-masonry elements such as windows, doors, etc. are not allowed.

#### 4.2.4. Arch Design-Build Description

Include a brief write up (maximum 2 pages) on the Team's arch construction and load testing, outlining the following information:

- A description and rationale of the arch design, material, and mortar selection;
- A photo of the arch following construction;
- Description of the monitoring set-up for loading;
- Discussion on the performance of the arch and any movement during the testing;
- Discussion on the failure load and the failure method (if applicable).

#### 4.2.5. Report Appendices

The report appendices do not count toward the report's word count or illustration limits, and shall include the following:

- Supplementary calculations from arch analysis (Section 4.2.2)
- Demonstration of dimensional compliance of the arch design-build (Section 4.1.2 and Figure 2)
- Mortar mix specifications including constituent ingredients (type and manufacturer), mix ratios, mixing procedure, and curing procedure (Section 4.1.1.2)
- Construction and Safety Protocol (Section 4.1.4)
- Table of the measured movements/deflections at each load increment (Section 4.1.5.2)

## 5. Phase 3: Finals

Up to five teams will be selected to advance to the competition finals at the APT Annual Conference. Finalists will be selected based on the quality of the Phase 2 submissions.

The finals provide the teams with an opportunity to meet and network with the Competition Judges, PETC members, and other conference attendees. The finals are also an opportunity for teams to demonstrate their knowledge of masonry arches, communication, and teamwork skills.

### 5.1. Posters

The Phase 3 competition finalists are to prepare a poster for presentation during the APT conference. The poster will act as a “guided tour” through the team’s project and should be a condensed version of the Phase 2 report. The poster should follow the general guidelines given in Appendix C.

### 5.2. Presentations

The team will give a presentation of their Phase 2 project to a panel of judges at the conference. Presentation requirements include:

- **Format:** PowerPoint (or similar) presentation slides with verbal presentation by student team members. The presentation should be max. 10 mins in length.
- **Presentation Content:** The presentation should summarize information from the Phase 2 report (historic research and structural analysis) and the design-build and testing process. Each student is to introduce themselves and speak for at least 1 minute.
- **Preservation Problems:** Following the presentation, the students will then respond to the two Preservation Problems. They are allowed 5 minutes maximum to answer both questions. See Section 5.2.1.
- **Q&A:** After each presentation, the team will have approximately 10 minutes for questions from the judges and conference attendees. The questions may be on the Phase 2 presentation/content or the answers to the preservation problems.
- **Judging Criteria:** The presentations will be judged on both content and quality/professionalism. All team members are encouraged to participate in the presentation and the Q&A session, and this will factor into scoring.
- **Total time:** 25 mins
  - Presentation: 10 mins
  - Preservation problems: 5 mins
  - Q&A: 10 mins

### 5.2.1. Preservation Problems

Teams will select a set of preservation problems during the conference. The PETC Competition Committee will show all problem sets to all teams and teams will select their problems in order, based upon their ranking from Phase 2.

**Teams are encouraged to engage conference attendees to discuss information to develop solutions for their selected preservation problems!**

Teams will have until their presentation to develop their responses to their preservation problems. Each team will share their solutions to the preservation problems as part of their main presentation. It is encouraged to use a slide/graphics to present the solutions. Different team members must respond to each question.

## 5.3. Dry Stack Arch Design-Build

Each team will participate in a dry stack arch design-build, which will occur under timed conditions at the conference, with viewing open to conference attendees.

The Phase 3 arch may be inspired by their Phase 2 work, but does not need to be a replica. Points will be deducted if teams do not meet all requirements and intent of the specifications. Scoring criteria and penalties for violations can be found in Appendix D.

### 5.3.1. Masonry Units

The masonry units can be made from any material, so long as the material and the units meet the following requirements:

1. Units must be of 'regular' shape commonly seen in masonry construction, with six-sides and no convex shapes (L-shapes, T-shapes, U-shapes). Units are to be joined with plane flat surfaces. No mortise and tenon, tongue and groove, and/or dowel type engagements are allowed.
2. No mortar, adhesive, magnetic, or mechanical attachments of units is allowed. Rubber or rubber-like materials will be deemed adhesive. A unit will be deemed adhesive if a piece of paper can hold to the underside of a unit.
3. The surface of the units should be less rough to the touch than 80 grit sandpaper. Competition judges will be the evaluators if questions arise.
4. All units must be safe for use in a hotel/conference environment.
5. Units cannot be made of a material that could easily shatter into pieces from improper handling, such as glass.
6. All units must be clean and leave no mess at the competition site.
7. The arch system must be composed of no fewer than 31 units. The largest unit must be no more than 3 times the size of the smallest.

- The maximum density for the material used in the arch is 125 lb/ft<sup>3</sup>(2000 kg/m<sup>3</sup>).

### 5.3.2. Material Weight and Volume Restrictions

The competition finals are designed to provide practical allowances for teams traveling various distances. Therefore, restrictions have been placed on material allowed:

- All units to be used in the arch **must fit inside 4 cases** (boxes/containers/suitcases) that would each be accepted as a checked-bag item on an airline. The maximum linear dimension is 62 inches (1580 mm) (length + width + height)
- Maximum weight is 50 lb (23 kg) per case
- Before construction, all cases containing arch components will be weighed. The empty weight of the cases will be subtracted from the total to determine the weight of the arch. The weight of the arch material will contribute towards the phase 3 score, see Appendix D.3.
- The weight of the tools, false work, PPE, and materials provided by APT, is not included in the arch weight and will not affect the Phase 3 score.

### 5.3.3. Assembly Requirements

The Phase 3 dry stack arch is to meet the requirements illustrated in Figure 3:

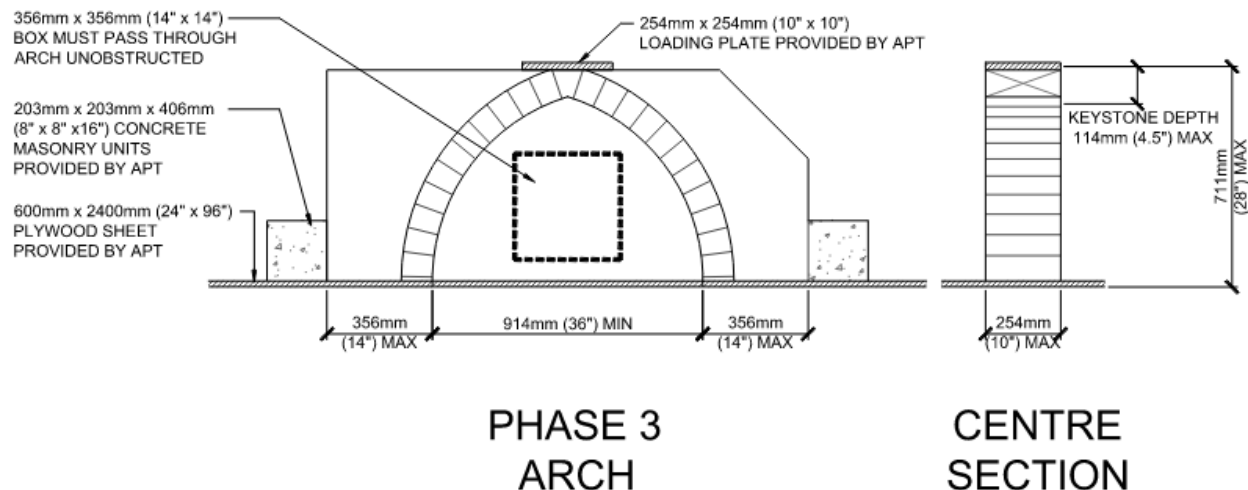


Figure 3: Sketch of the Phase 3 arch dimensional requirements and test set-up. Diagram is representative of dimensional and testing requirements; team's arches do not need to look identical to the arch shown.

### 5.3.4. Dry Stack Arch Construction

All conference construction work will be carried out under the supervision of PETC. Each team will be designated a construction area by APT.

Protective blankets for the build area will be provided by APT. A 24-inch x 48-inch (610mm X 1219 mm) sheet of plywood will be placed on the protective blankets. This is the surface on which the arch will be built. Each team will have two 8-inch x 8-inch x 16-inch (203 x 203 x 406 mm) concrete masonry units provided to them by APT. These concrete blocks are to be placed on the plywood sheets against each side of the arch. See figure 3.

- Prior to construction, all materials must be inside their respective cases, with the construction area marked out and blankets down.
- All team members involved with the arch construction and loading must wear gloves, safety glasses, and steel toed boots. Teams are responsible for the safe erection of the arch.
- All teams will construct their arches simultaneously. Each team will be provided with a timekeeper. The speed of the build will count towards the Phase 3 score.
- All masonry units are to be put in place one at a time, as is done in conventional practice. No placing of units in groups or tilt-up construction will be allowed.
- When all units have been placed and the plywood loading square has been placed on the arch, the timer stops and the final time will be recorded.

If competition organizers or judges feel that a team's construction practices are unsafe, they will request that the team halt construction. Teams will be allowed appeal to the judging panel for any requested stop; however, the time will continue during this process. If the appeal finds that safety issue has been adequately addressed, then they may continue the build. If the construction is deemed unsafe, the team must disassemble and reassemble or receive last place in the conference build.

#### 5.4. Load Testing

The arches will be tested one at a time under the direction of PETC and Judges. Prior to loading, judges will ask each team to discuss the expected failure mode of their arch.

Testing will be performed by loading the arches with pre-defined masses up to a maximum of 220 lb [100 kg]. Each will apply the load to their own arch. Loading may only be done by individuals wearing the required personal protective equipment.

No lateral loads will be applied. Deflections will not be measured or judged.

The arch will be deemed to have failed if more than one unit has fallen, or, the arch collapses within 30 seconds of loading.

Arches that do not fail under the load test will be unloaded and may be left in place for viewing by the conference attendees. Teams are responsible for clean-up and removal of their arches by the required date/time defined by PETC or the APT Conference Committee.

## Appendix A: Phase 2 Report Format

The report should clearly identify the following:

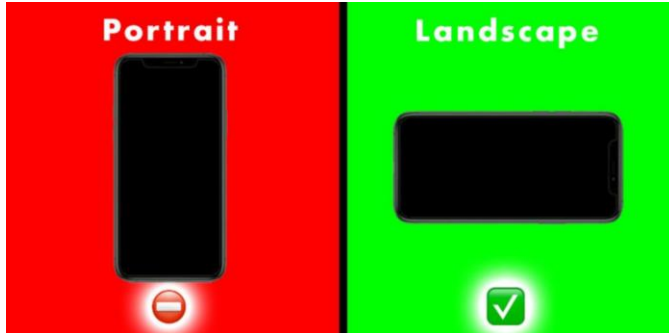
- Project Title
- Name of institution, individual team members, Faculty Advisor(s), and mentors
- References (educational references, literature, etc.)

The report should be formatted as per below:

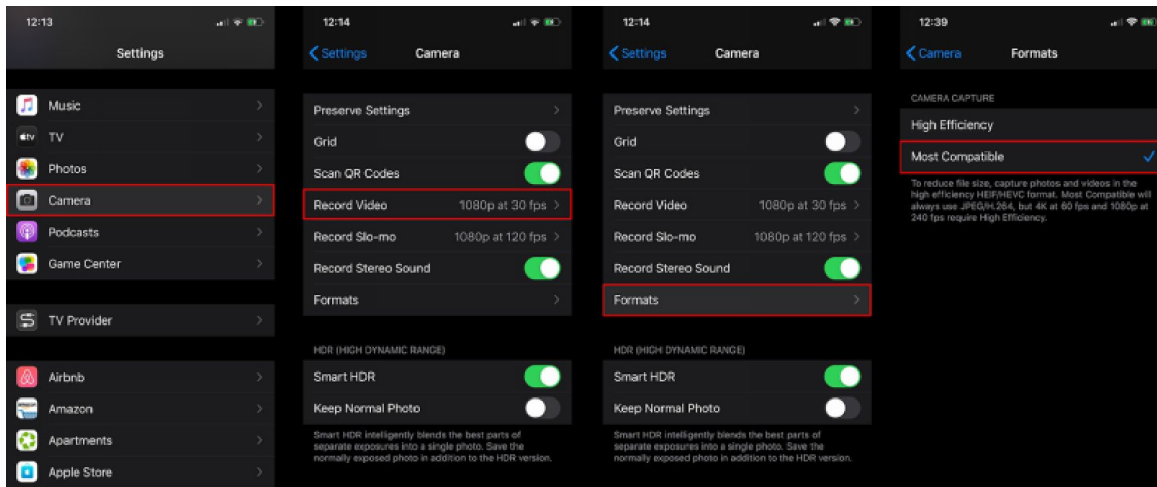
- Word count: 3000-5000
- Page size: Letter (8-1/2 inches x 11 inches), Portrait orientation
- Font sizes:
  - Title/Headings: Calibri, size 14
  - Subheadings: Calibri, size 11
  - Body: Calibri, size 11
- 6 to 10 illustrations (including tables)
  - Each illustration must have its own label (Fig. 1, Fig. 2, not Fig. 1a, 1b) and caption.
  - Indicate illustration source at end of each caption (if not produced by the team).
  - Illustrations should be referenced within the body of the report.
- For references, bibliography, and other matters of style, authors must follow a recognized citation style, such as Chicago, IEEE, or APA.

## Appendix B: Phase 2 Video Requirements

- Record videos in .MOV or .MP4 file type.
- Use the landscape orientation.



- Android phone/tablets: Adjust camera settings to 1080p resolution.
- iPhone/iPad users:
  1. Select “Camera” settings
  2. Select “Record Video” settings and select “1080p at 30fps”
  3. Select “Formats” and select “Most Compatible”



- If the team needs to record the Arch Build using more than one MOV/MP4 file, then each file must be named using the following naming convention:  
*Institution\_Build\_File #*
- If the team needs to record the Arch Load Test using more than one MOV/Mp4 file, then each file must be named using the following naming convention:  
*Institution\_Load\_File #*

PETC will provide a link to a shared folder on Google Drive to upload your files. The link will be provided prior to the Phase 2 submission deadline.

## Appendix C: Phase 3 Poster

**The poster shall include the following content. Any additional information referenced but not included on the Poster will not be reviewed.**

- Project Title
- Name and insignia of institution
- Names of team members
- Phase 2 summary:
  - Name and location of structure
  - Material makeup (masonry type, mortar type, etc.)
  - Date of construction and construction methods
  - Present the Phase 2 structural analysis findings
    - A brief statement of the Preservation Plan from the report
- Acknowledgements: Names of Faculty Advisor(s), APT mentors, collaborators, donors, etc. who aided in the work (including funding, materials, and other resources)
- References (educational references, literature, etc.)

**Poster format shall be as follows:**

- 36 inches (91.4 cm) high x 48 inches (121.9 cm) wide, Landscape orientation
- Font: Readable font with sizes below:
  - Title/Headings: size 130 (minimum)
  - Subheadings: size 54 (minimum)
  - Body: size 32 (minimum)
- Four to ten illustrations (including tables):
  - Each illustration must have its own number (Fig. 1, Fig. 2; not Fig. 1a, 1b) and its own caption. Indicate citation at end of each caption (if not produced by the team). Images should be referenced within the narration of the poster.
  - Illustrations should be a minimum 100 dpi and imported at the same size they will be on the poster (or smaller). Ideal resolution for posters is 150 dpi.
  - Illustration size is at the discretion of the team but should be large enough to be read/interpreted clearly. Many institutions have examples of research poster presentation templates and tips are available online.

*Poster Tip: Keep presented information simple. This poster will be read by judges and conference attendees who will want to know only the most important aspects of the project. The viewers should be able to review the poster within 5 minutes.*

**Printing, transportation, and set-up of the poster is the responsibility of the team.** Teams are to supply poster board for mounting their posters on an easel or table provided by APT.



## Appendix D: Scoring

Submissions will be reviewed by the PETC Competition Committee and the Competition Judges. The Committee and Judges will act in good faith to conduct objective and fair evaluations to the greatest extent possible. Final scoring will be at the Judges' discretion. Numeric score or weighting may be changed by PETC; if so, PETC will notify all teams in writing in advance of the relevant Phase submission deadline.

Teams must pass Phase 1 to proceed to Phase 2. Teams will be notified via email of their Phase 1 acceptance. Phase 2 submissions are evaluated to determine the finalist teams for Phase 3. Phase 2 ranking also determines the order of Preservation Problem selection during Phase 3.

During the APT Conference, a group of selected professionals from different sectors of the design and construction industry will form the Judges' panel. The Judges will evaluate the Phase 3 posters, Preservation Problems, and the conference build.

### D.1 Phase 1 Scoring

DELIVERABLE	CRITERIA	SCORE
Notice of Participation	Submission includes all required team and team member information.	Pass/Fail
Masonry Arch Selection	Submission narrative document includes all required information, including references and images.	Pass/Fail

### D.2 Phase 2 Scoring

DELIVERABLE	CRITERIA	MAX. SCORE
<b>Report</b>	Historic Research and Design Review (Section 4.2.1) <ul style="list-style-type: none"> <li>· Historic significance of selected arch</li> <li>· Identification of materials used in construction</li> <li>· Previous interventions</li> <li>· Description of arch</li> </ul>	10
	Structural Analysis (Section 4.2.2) <ul style="list-style-type: none"> <li>· Loads, load cases, and assumptions are documented.</li> <li>· Two analysis methods are implemented, each analysis method is clearly described, and each</li> </ul>	25

	<p>analysis method provides required calculations and/or graphics.</p> <ul style="list-style-type: none"> <li>· Discussion of structural analysis findings</li> <li>· Supplemental calculations and additional analysis are presented in an Appendix.</li> </ul>	
	<p>Arch Design</p> <ul style="list-style-type: none"> <li>· Design approach and discussion</li> </ul>	20
	<p>Preservation Plan (Section 4.2.3)</p> <ul style="list-style-type: none"> <li>· Identify conditions</li> <li>· Judgement of potential causes and severity</li> <li>· Recommended interventions for repairs</li> </ul>	15
<b>Design-Build</b>	<p>Construction</p> <ul style="list-style-type: none"> <li>· All materials are documented</li> <li>· All dimensions meet the requirements of Section 4.1.2</li> </ul>	20
	<p>Loading</p> <ul style="list-style-type: none"> <li>· All loading procedures meet specifications</li> <li>· All loading increments and displacements/ deflections are documented</li> <li>·</li> </ul>	5
	<p>Protocol Deductions</p> <ul style="list-style-type: none"> <li>· Deduct points for safety/PPE violations</li> <li>· Deduct points for use of non-masonry materials (except falsework)</li> <li>· Deduct points for use of admixtures, bonding agents, etc.</li> <li>· Deduct points for dimensional violations</li> <li>· Deduct points for loading violations</li> </ul>	n/a
	<p>Build and Load Videos</p>	5
		<b>100</b>

**D.3 Phase 3 Scoring**

<b>DELIVERABLE</b>	<b>CRITERIA</b>	<b>MAX. SCORE</b>
<b>Poster</b>	<ul style="list-style-type: none"> <li>· Format conforms to the specifications</li> <li>· All required content is provided on the poster</li> <li>· Posters are legible</li> <li>· Content is engaging and describes the team’s project and unique features</li> </ul>	10
<b>Presentation</b>	<ul style="list-style-type: none"> <li>· Each team member presents</li> <li>· Points will be credited for clarity, relevance, interest, and staying within the time limit</li> <li>· Points will be deducted for going over the time limit</li> </ul>	20
<b>Preservation Problems</b>	<ul style="list-style-type: none"> <li>· Different team members present</li> <li>· Points will be awarded for correct and thoroughness of responses. Credit will also be given for connecting a response to a real-world situation, such as elements researched or observed from the course of this competition.</li> </ul>	20
<b>Q&amp;A</b>	<ul style="list-style-type: none"> <li>· Different team members answer questions</li> <li>· Points will be awarded for clarity of responses</li> <li>· Questions will be asked about the content of the Phase 2 portion of the presentation as well as the Preservation Problems</li> </ul>	10
<b>Dry Stach Arch Build and Loading</b>	<b>Build Speed</b> <ul style="list-style-type: none"> <li>· Quickest build: 10/10</li> <li>· Second quickest build: 8/10</li> <li>· Third quickest build: 6/10</li> <li>· Fourth quickest build: 4/10</li> <li>· Fifth quickest build: 2/10</li> </ul>	10
	<b>Arch Strength</b> <ul style="list-style-type: none"> <li>· Sustain load of 220lb (100 kg): 15/15</li> <li>· Sustain load of 200lb (90 kg): 14/15</li> <li>· Sustain load of 175lb (80 kg): 13/15</li> <li>· Sustain load of 155lb (70 kg): 11/15</li> <li>· Sustain load of 130lb (60 kg): 9/15</li> <li>· Sustain load of 110lb (50 kg): 7/15</li> </ul>	15

	<ul style="list-style-type: none"> <li>· Sustain load of 55lb (25 kg): 5/15</li> <li>· Sustain load of 25lb (10 kg): 3/15</li> <li>· Sustain self-weight and plywood plate: 2/15</li> <li>· Incomplete 0/15</li> </ul>	
	<p>Arch Weight</p> <ul style="list-style-type: none"> <li>· Lightest weight: 10/10</li> <li>· Second lightest weight: 8/10</li> <li>· Third lightest weight: 6/10</li> <li>· Fourth lightest weight: 4/10</li> <li>· Fifth lightest weight: 2/10</li> <li>· Exceeds maximum allowed weight: 0/10</li> </ul>	15
	<p>Penalties</p> <ul style="list-style-type: none"> <li>· Safety/PPE violations (-5 points)</li> <li>· Dimensional violations (-3 each)</li> <li>· Material violations (-5 points)</li> <li>· Judges may administer additional penalties for safety and complain violations at their discretion.</li> </ul>	n/a
<b>TOTAL POSSIBLE SCORE</b>		<b>100</b>

<b>FINAL SCORE</b>
$Final\ Score = \frac{1}{3}(Phase\ 2\ Score) + \frac{2}{3}(Phase\ 3\ Score)$



## Appendix E: Conference Financial Information

PETC will pay the APT conference registration fee (non-ticketed events) for up to 6 students, and up to 3 hotel rooms, for each of the up to five (5) teams selected to attend the Phase 3 Finals. The finalist teams will be selected based on the quality of the Phase 2 submissions.

Details will be provided to Finalist teams. All other expenses (travel, extended stay, additional lodging, food, competition materials, etc.) are the responsibility of the teams. The PETC will not financially support any Faculty Advisors or mentors.

Each team is to raise money for their expenses. One of the values in a competition of this nature is that it allows and encourages students to reach out to companies to ask for support, and while doing so, make connections that may be of future value. The PETC Competition Committee can provide a general list of potential sponsors to share with the teams upon request to assist in finding potential sources of sponsorship, especially pertaining to the masonry industry for this year's competition. Teams are encouraged to define their own ways in which to acknowledge the support they received (sponsored T-shirts, posters, etc.).

Each team is to develop their own financial plans, including all anticipated costs and anticipated funds raised, to be included in the Phase 2 submission if the team intends to vie for travel to the APT Conference. The Competition Committee will use these plans to help teams that may be short of travel funds.

Teams should make their own travel arrangements and are responsible for travel visa application and costs if required. APT may be able to support or sponsor a visa; please contact the PETC Competition Committee if this is needed.